In-Situ Adaptation and Coastal Vulnerabilities in Ghana and Tanzania

Jeasurk Yang¹, Victor Owusu¹, Edo Andriesse¹, and Austin Dziwornu Ablo²

Abstract
Coastal fisheries communities in sub-Saharan Africa are under high socioeconomic vulnerability in the face of environmental pressures. This article contributes to the current adaptation debate by revisiting the benefits of in-situ adaptation. We assess possible in-situ adaptation strategies amid ongoing vulnerabilities by comparing Ghana and Tanzania. A total of 441 household surveys were conducted in four study sites. The major findings of the study are as follows: First, the three major in-situ adaptation strategies are regular changes of nondestructive fisheries techniques, alternative occupations, and collective action. Second, all three strategies have a significant relationship with income change. Finally, the communities in Tanzania utilized all three strategies more and performed better economically than those in Ghana. On the basis of these insights, we suggest implications of in-situ adaptation for future coastal development in sub-Saharan Africa.

Keywords
small-scale fisheries, in-situ adaptation, poverty reduction, coastal livelihoods, climate change, Ghana, Tanzania

Many coastal communities in the global South continue to heavily depend on fisheries and aquaculture. Consequently, climate change and its associated extreme weather events, as well as socioeconomic vulnerability from practices such as illegal fishing and overfishing, have adverse impacts on small-scale fisheries ecosystems (Badjeck, Allison, Halls, & Dulvy, 2010; Brander, 2010).

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Sub-Saharan Africa is among the vulnerable regions with higher sensitivity and lower adaptive capacities in relation to the impacts of climate change and other environmental pressures (Allison et al., 2009). In this context, a key challenge for rural coastal development is how adaptation strategies can lead to sustainable livelihoods (Allison & Ellis, 2001).

This article focuses on in-situ adaptation. Among adaptation strategies, in-situ adaptation is defined as localized adjustment to climate change and other environmental pressures. However, in-situ adaptation has received less attention in comparison to other strategies, especially out-migration (Castells-Quintana, Lopez-Uribe, & McDermott, 2018). This is mainly because the former is usually seen as submitting to vulnerability, while the latter as reducing it in the long run (Scheffran, Marmer, & Sow, 2012).

Nevertheless, in this article, we argue that in-situ adaptation should be seriously considered, particularly considering the following circumstances often found in sub-Saharan Africa: (a) insufficient support from government agencies and nongovernmental organizations (NGOs), (b) significant continuing dependency on fisheries in many countries, and (c) low expected advantages from migration. Successful in-situ adaptation could also culminate in less rural–urban migration to already overburdened metropolises such as Lagos, Luanda, Mogadishu, Nairobi, Accra, and Dar es Salaam. In-situ adaptation could play an important role in contributing to a “revitalization of the world’s countryside” and less severe spatial inequalities (Liu & Li, 2017, pp. 275–277). Therefore, it is important to understand which in-situ strategies are viable, how to bring them about, and how to foster collaboration to ensure effectiveness. This article contributes to the current adaptation debate by revisiting the benefits of in-situ adaptation. Our purpose is to assess possible in-situ adaptation strategies amidst vulnerability. We use a comparative case study of communities in two sub-Saharan African countries: Ghana and Tanzania. These countries present suitable comparative cases as coastal communities in both countries are heavily dependent on fisheries and aquaculture and face various vulnerabilities including climate change, illegal fishing, and overfishing. The empirical inquiry is based on surveys among a total of 441 fisherfolk households in four study sites. We address the following four research questions:

1. What are the common vulnerability conditions in coastal small-scale fisheries communities in Ghana and Tanzania?
2. What are the in-situ adaptation strategies deployed by these communities, and how effective are these strategies in building resilience?
3. Comparing the four study sites, under what conditions does in-situ adaptation thrive?
4. What are the implications of our results for coastal development in sub-Saharan Africa?
This article begins with an overview of the coastal fisheries communities, focusing on the concepts of in-situ adaptation and vulnerability. This is followed by a section introducing case study sites and methods. The first empirical section presents general findings and provides answers to Research Questions 1 and 2, while the second empirical section along with the discussion section delves deeper into the empirical material by comparing the four study sites. As such, it seeks to answer Research Question 3. Finally, the conclusion summarizes the main results and discusses implications for future coastal development, thereby addressing Research Question 4.

**Literature Review: Vulnerability and In-Situ Adaptation in Coastal Areas**

**The Benefits of In-Situ Adaptation in Sub-Saharan African Fisheries Communities**

In-situ adaptation has been frequently discussed in earlier studies as a potential measure to strengthen livelihoods and localities but without explicitly using the term *in-situ adaptation* (e.g., Rodima-Taylor, 2012). The term was introduced to distinguish community-based and site-specific adaptation from migration involving movement across space. In-situ adaptation options can include strategies such as diversification, intensification, and innovation (Thorn, Thornton, & Helfgott, 2015). Although these options have been discussed in the adaptation literature, they usually have not been explicitly classified as an in-situ adaptation.

The main concept of this article is in-situ adaptation (Sakdapolrak, Promburom, & Reif, 2013; Sharma & Franks, 2013). In-situ adaptation was only defined as the opposite side of out-migration (e.g., Tan & Liu, 2013: 11). We specifically define in-situ adaptation as a localized adjustment to climate change and other environmental pressures and their impacts on existing locations without undertaking out-migration. The definition could include cases of income diversification while remaining in the original occupation. Simultaneously, we designate out-migration as movement across space and sectors (Castells-Quintana et al., 2018), such as rural–urban migration.

The discussion on whether in-situ adaptation or out-migration is more favorable in developing countries started in public debates related to climate change policies. In these public debates, migration was frequently perceived as resulting from failures of adaptation strategies while the (in-situ) adaptation was seen as a positive outcome of effective development interventions (Gemenne & Blocher, 2017). However, in the last decade, migration as a potential positive adaptation strategy has increasingly received more attention (McLeman & Smit, 2006), while relatively few scholars have focused on the significance of in-situ adaptation (Sharma & Franks, 2013). This is because in-situ adaptation has sometimes
been considered as a suboptimal rather reactive strategy (submitting to vulnerabilities), while migration has been viewed as reducing vulnerability in the long run (Castells-Quintana et al., 2018) and improving resilience (Scheffran et al., 2012). Thus, Castells-Quintana et al. (2018) argued that governments need to intervene with policies such as (a) providing infrastructure, (b) access to financial services, (c) cash transfers and social safety nets, and (d) providing information, incentives, and property rights, to foster economic transformation.

Although migration could be a long-term transformational solution, we suggest, as introduced in the previous section, that in-situ adaptation deserves greater attention in sub-Saharan Africa. First, although the policies for out-migration and economic transformation need massive external funds from the government or NGOs, communities in sub-Saharan Africa are suffering from insufficient support. Second, at the national scale, aquaculture and fisheries are expected to continue to play important roles in coastal sub-Sahara Africa in terms of gross domestic product, employment, and food security (de Graaf & Garibaldi, 2014). Moreover, demand for fish is estimated to increase by 30% by 2030 according to the World Bank (2013). Third, rural–urban migration might not be an attractive option for fisherfolk without secure employment opportunities, considering low educational attainments and lack of other skills (The Africa-America Institute, 2015). It would be a huge task for urban governments and institutions to accommodate and manage large numbers of new migrants in already congested cities with a large number of people living in slums (United Nations Department of Economic and Social Affair [UN DESA], 2018). While we do not disapprove of migration out of rural coastal areas, a priori, we assert that in-situ adaptation could work as a sustainable and inclusive strategy to improve coastal livelihoods in sub-Saharan Africa. For the most remote and problematic locations, out-migration might ultimately prove to be the only way out of poverty.

Marine-Based In-Situ Adaptation (Intensification and Innovation)

Marine based in-situ adaptation as used in this article refers to community-based and site-specific adaptation strategies that are deployed by fisherfolk. These may include changing fishing gear to target new species, increasing fishing efforts, and adopting marine aquaculture (mariculture). Across sub-Saharan Africa, fisheries contribute significantly to food security and serve as a source of livelihood. It is estimated that about 200 million people in Africa depend on fish as their source of animal protein intake, while another 90 million depend on fisheries as part of their diversified livelihood strategy (Motta, 2015). In recent decades, issues of overexploitation of fisheries resources in many developing countries have received considerable attention (Perry & Sumaila, 2007; Wallner-Hahn et al., 2016). Overfishing and illegal and unreported fishing have pushed many
peripheral coastal communities into more vulnerable socioeconomic conditions, if not poverty (Tanner et al., 2014).

In the midst of decreasing fish catches, many small-scale (artisanal) fishers in developing countries have intensified their fishing efforts (increase in fishing time and in crew members) together with the use of destructive and unsustainable fishing techniques with the hope of catching more fish (Perry & Sumaila, 2007). In Mozambique, Blythe, Murray, and Flaherty (2014) found that fishers in Zalala have not only switched from the use of seine nets to gill nets to target new species but have also increased the duration of individual fishing trips. In Ghana, even though artisanal fishers do not regularly change their fishing gear, their vessels target new species (Belhabib, Lam, & Cheung, 2016). The ability of fishers to switch to a more sustainable type of gear is constrained by a lack of capital, traditions, and the accessibility of drag nets (Perry & Sumaila, 2007).

Besides overfishing and illegal fishing, climate change has increasingly threatened the livelihoods of coastal communities across Africa. Sea-level rise and extreme weather events (storm surges, strong winds, ocean warming, and recurrent flooding) also damage coastal community assets such as landing sites, boats, fishing gear, houses, and schools (Badjeck et al., 2010). The Agulhas and Somali Current Large Marine Ecosystems report in 2013 showed how the impacts of climate change are threatening Tanzania’s low-lying coastal areas and marine ecosystems, water resources, and coastal infrastructure. In addition, Belhabib, Lam, and Cheung (2016) have also showed how climate change and overfishing have contributed to the transformation of species composition of fisheries catches in West Africa including Ghana.

The national fisheries development plan of Ghana (2015–2019) also recognized the need to regulate the number of new entrants into the artisanal fishing sector. To achieve this, the promotion of aquaculture including mariculture as an alternative livelihood option was proposed. The adoption of marine aquaculture can be a major innovation that holds the potential to contribute to sustainable livelihoods and secure food security. Currently, the fisheries sector in Ghana comprises these proportions of production types: marine fishing (70.6%), inland fishing (18.8%), and aquaculture (11.3%) (Ministry of Fisheries and Aquaculture Development [MOFAD], 2016). With aquaculture accounting for only 11.3% of total fisheries output, the prospects for diversification into marine aquaculture could be promising.

Compared to Ghana, Tanzania has had a long history with marine-based seaweed farming, especially in Unguja (van Hoof & Kraan, 2017). Even though current production is mostly on a small-scale basis, this subsector contributes significantly to small-scale fishing household incomes (Bolten, 2017). Unlike Ghana, inland fish production constitutes the largest production type, at 85%, followed by marine (14%) and only 1% for aquaculture (Ministry of Agriculture, Livestock and Fisheries [MALF], 2016). The adoption of aquaculture in Tanzania is comparatively lower. Government ineffectiveness and little
private-sector participation have stifled the growth of aquaculture (MALF, 2016). With aquaculture production in 2015 accounting for only 1% of the total, there are ample opportunities for marine aquaculture production in Tanzania. Currently, marine aquaculture production consists mainly of tilapia, milkfish, and pearl oysters with the potential for an integrated farming system (cultivation of several species) together to ensure efficient use of resources (van Hoof & Kraan, 2017). The MALF estimates that between 15,000 and 20,000 people are engaged in seaweed cultivation and another 3,000 are engaged in the marine sector (MALF, 2016).

**Non-Marine-Based In-Situ Adaptation (Diversification and Innovation)**

By the use of non-marine-based in-situ adaptation, we refer to income generating activities from nonfisheries resources situated at the community level. Examples of such economic activities may include farming, tourism, petty trading, and craft making. Encouraging coastal households to decrease overfishing cannot be successful without facilitating viable nonfishing alternatives in which they have reason to invest in. However, Brugère, Holvoet, and Allison (2008) argued that diversification into other marine and non-marine-based products may not necessarily guarantee positive outcomes and poverty reduction. In developing countries, national governments seem to play a vital role in formulating and introducing policies and programs that aim to ameliorate the livelihoods of coastal communities, although these policies seldom translate into livelihood transformation.

Ghana’s MOFAD has set up steering committees charged with the responsibility of implementing alternative livelihood programs with support from the World Bank, with the aim of reducing overdependence on marine resources. In addition, a revolving fund credit scheme has been set up for small-scale fish farmers, processors, and traders to facilitate the disbursement of credit to groups with 5 to 10 members (MOFAD, 2018b). As we mentioned earlier, these policies have done little to transform the livelihoods of coastal households. As artisanal fishers have low adaptive capacity to climate change and other environmental vulnerabilities, intensification of fishing remains a major adaptation strategy (Belhabib et al., 2016; Perry & Sumaila, 2007). Asiedu and Nunoo (2013) found that less than 20% of surveyed fisherfolk in four selected coastal communities in Ghana have other jobs besides fishing. Those who had jobs were engaged in crop farming, livestock rearing, and petty trading. Successful alternative livelihood schemes would have to address some fundamental problems such as skills training for available jobs opportunities (Asiedu & Nunoo, 2013).

In Tanzania, several scholars (Brugère et al., 2008; van Hoof & Kraan, 2017) have identified multiple alternate income-generating activities besides fishing. These include farming, tourism-related jobs (boat rides, hotel staff, fishing guides), crab fattening, small businesses, trading in wood, making of charcoal,
stone quarrying, palm winemaking, and lime and salt production. In Mozambique, the majority of fishers at Inhangome have turned to various non-marine jobs in response to decreasing fish catches. Among them are retail sales of clothing, alcohol, and chicken; harvesting of wood from mangroves; and bicycle repairing (Blythe et al., 2014). Livelihood diversification at the level of individual households could be constrained by several factors such as education, the perception of risk, migration, social networks and kinships, financial resources, and the availability of land (Brugère et al., 2008). For coastal communities blessed with beautiful beach scenery, tourism is also an option. The development of village coastal tourism enterprises could provide direct and indirect jobs to coastal communities. Such initiatives could be championed by the local districts or municipal assemblies in collaboration with national governments, the private sector, and foreign stakeholders. However, coastal tourism is highly dependent on natural resources which make it vulnerable to incidences of extreme weather events and other natural disasters (Santos-Lacueva, Clavé, & Saladié, 2017).

**Study Areas and Methods**

**Case Introduction**

Ghana in West Africa and Tanzania in East Africa were selected to obtain insights into in-situ adaptation in sub-Saharan African coastal communities in different institutional and vulnerability contexts (Figure 1 and Table 1). From the start, it made sense to consider Ghana as a site for empirical inquiry since the second and fourth author are Ghanaian. Tanzania was selected as an ideal country for comparative reflection because of the presence and vulnerability of fishing communities living in a different part of coastal sub-Saharan Africa as well as the practical advantage of the English language as a widely spoken language.

Both countries well represent the circumstances of coastal fisheries communities in sub-Saharan Africa. First, both are eligible for UN status as among the Least Developed Countries (LDC).² Gross national income per capita in Ghana and Tanzania were measured at $1,380 and $900 (US dollars) in 2016. Moreover, the worldwide governance indicators were low in Ghana (–0.20) and Tanzania (–0.55) in 2016 (World Bank, 2017a). Both indicators show that the countries are suffering from insufficient financial resources, weak governance, and ineffective top-down adaptation strategies, although Ghana generally performs better than Tanzania.

Second, the coastal communities in the two countries are highly dependent on fisheries economies and are struggling with climate change and socioeconomic vulnerability. Even on Unguja Island, where tourism has provided job opportunities, many households continue to be “clustered around the poverty line” and face hardships (World Bank, 2017b, p. 55). About 2 million people in Ghana and 4 million in Tanzania are engaged in the fisheries sector (MALF,
2016; Mkama et al., 2010). Marine and inland fisheries contribute 1.4% of Ghana’s gross domestic product (Tanner et al., 2014) and 2.4% of Tanzania’s (MALF, 2016). However, the countries are currently struggling to rebuild their fish stock as a result of overfishing, illegal fishing, and climate change (Atta-Mills, Alder, & Sumaila, 2004; Nunoo et al., 2014; Perry & Sumaila, 2007). In Ghana, the MOFAD together with the Fisheries Commission has introduced a closed fishing season for industrial trawlers as part of measures to rebuild the dwindling fish stocks. Between 2016 and 2018, three separate closed seasons were enforced for a duration of 2 months for each closure (MOFAD, 2018a).

Third, continuing rural–urban migration is likely to put more pressure on Ghana’s and Tanzania’s largest cities. According to UN DESA (2018), annual urban population growth rates until 2050 in Ghana and Tanzania are expected to be 2.6% and 4.3%, respectively. Especially in the case of Tanzania, the rate is ranked the fifth in the world. Improved in-situ adaptation leading to stable livelihoods would thus be a welcoming trend and might help convince rural inhabitants to stay.

Data Collection and Analysis

The data for this study consist of primary and secondary sources. Empirical data collection is made up of fisherfolk household surveys. A total of 441 household
<table>
<thead>
<tr>
<th>Country Site</th>
<th>Ghana</th>
<th>Tanzania</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ada East district (N = 110)</td>
<td>Keta municipality (N = 114)</td>
</tr>
<tr>
<td>Villages</td>
<td>Azizanya and Kewunor</td>
<td>Adzido and Vodza</td>
</tr>
<tr>
<td>Population</td>
<td>2,830 (2 villages)</td>
<td>3,369 (2 villages)</td>
</tr>
<tr>
<td>Average household size</td>
<td>6.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Educational attainment</td>
<td>No education 33 (30.0%)</td>
<td>No education 19 (16.7%)</td>
</tr>
<tr>
<td></td>
<td>Elementary 63 (57.3%)</td>
<td>Elementary 65 (57.0%)</td>
</tr>
<tr>
<td></td>
<td>Upper level 14 (12.7%)</td>
<td>Upper level 29 (25.4%)</td>
</tr>
<tr>
<td></td>
<td>N/A 1 (0.9%)</td>
<td></td>
</tr>
<tr>
<td>Commonly caught fish</td>
<td>Tuna, redfish, yellowtail fish</td>
<td>Anchovy, herring, tuna, redfish</td>
</tr>
<tr>
<td>Common fishing gear</td>
<td>Purse seines, beach seines, set nets, draft gill nets, hook, and line</td>
<td>Purse seines, beach seines, set nets, hook, and line</td>
</tr>
<tr>
<td>Median monthly fisheries income (USD)</td>
<td>110.0</td>
<td>132.0</td>
</tr>
<tr>
<td>Average monthly fisheries income (USD)</td>
<td>100.6</td>
<td>154.8</td>
</tr>
<tr>
<td>Top 3 problems in villages</td>
<td>Illegal fishing 18.6%</td>
<td>No harbor 25.0%</td>
</tr>
<tr>
<td></td>
<td>Unemployment 15.6%</td>
<td>Unemployment 24.0%</td>
</tr>
<tr>
<td></td>
<td>Flooding 12.3%</td>
<td>Lack of premixed fuel 10.0%</td>
</tr>
</tbody>
</table>

surveys were conducted in Ghana and Tanzania in December 2017 and January and February 2018. In Ghana, a total of 110 and 114 surveys were conducted in Ada district (Aziznya and Kewunor) and Keta municipality (Adzido and Vodza), respectively. In Tanzania, 109 surveys were conducted in four villages in the Bagamoyo district (Dunda, Kaole, Pande, and Mlingotini), and 108 surveys in four villages on Unguja Island of Zanzibar (Nungwi, Mkokotoni, Kizimkazi Dimbani, and Kizimkazi Mkunguni; see Figure 1). All four research areas can be classified as impoverished (Table 1). Oral permission for study sites in Ghana and Tanzania was sought from the elders of communities and the chief fishermen. Community leaders were selected through simple random sampling, and respondents were selected through snowball sampling where we asked respondents to recommend/suggest other participants who can provide valuable information (Penny, Wilson, & Rodwell, 2017). The questionnaire survey was divided into four broad topical areas of inquiry covering basic socioeconomic information, systems of fishing practices and adaptation strategies, climate change, and collective action. Closed, open, and multiple-choice questions were utilized to generate a set of data suitable for providing in-depth details into the issues under discussion. Whereas the closed-ended questions compelled respondents to narrow down only on specific choice of answers the open-ended questions offered the respondents to freely talk about their experiences and knowledge related to the local fishing industry and other penitent issues that ensued from the closed-ended questions. On the basis of the type of adaptive responses mentioned by respondents, we extracted in-situ adaptation strategies based on our definition. The questionnaire survey lasted from 45 min to an hour on average.

The questions asked pertained to basic household structure, fishing activities (technique and tools, domestic or commercial, issues of illegal fishing and experience), alternate livelihood options (farming, land ownership, remittance), and knowledge and perception of climate change-related issues. The surveys were conducted in English and local languages (Ga, Twi, Ewe, and Swahili) with four research assistants from the University of Ghana and three from the University of Dar es Salaam. Some of the respondents approached were initially hesitant to participate in the survey due to perceived negligence by the national government to revive the fishing industry over past years. That notwithstanding, those who eventually participated in the survey had a good knowledge of the questions that were posed and provided satisfactory responses. Furthermore, statistical extraordinary outliers were deleted during data processing. Secondary data were collected from published materials from national statistical websites, district and municipal reports, USAID reports, and other online sources.

The software applications SPSS (version 21.0) and Microsoft Excel were used to analyze the collected data. Along with descriptive statistics, chi-square tests of independence were utilized to examine the significant relationships between in-situ adaptation strategies and fish catch/income changes and to determine the
applicability of the strategies. Our analysis focuses on findings that are robust: findings with an effect size ≥ Cohen’s definition of “small” (phi coefficient ≥ 0.1) (Cohen, 1992).

**Vulnerabilities and In-Situ Adaptation Strategies**

Table 1 shows the sociodemographic features of the surveyed communities. The majority of fisherfolk surveyed had an elementary school education except for Unguja Island, where about 50% of the respondents had attained upper level/secondary. Only Bagamoyo had an average household size of 5; the rest of the surveyed communities had a household size of 6. A lack of job opportunities remained a major problem in Ada East, Keta, and Bagamoyo. On Unguja Island, poor water quality was the most important issue for the surveyed households.

Table 2 presents key results of the surveys among 441 fishing households. It comprises three parts: (a) the extent to which they experience vulnerability caused by climate change and illegal or overfishing, (b) the lack of external support and the necessity for in-situ adaptation in those fisheries communities, and (c) the level of usage of in-situ adaptation strategies in the communities. These three issues are discussed in the following.

**Vulnerability of Coastal Fisheries Communities**

The first two rows of Table 2 show that all the communities are under commonly found vulnerability caused in two ways: fish catch quantity changes in recent years and income changes compared to 5 years ago. First, the majority of respondents reported that fish catches have decreased, while only a few have experienced increases in all sites. Moreover, the general trends of income situations are downward in all the communities, although the Tanzanian communities show a higher proportion of fisherfolk whose income has increased recently.

However, the reasons that fishermen gave slightly differed from research area to research area (Figure 2). In this study, the perception of climate change-related impacts on fisheries was found to be more severe in study sites across Tanzania compared to Ghana. In Bagamoyo and Unguja, an average of 41% compared to just about 3% of fishers in Ada East and Keta attributed declining fish catch to climate change impacts. The most commonly cited form of climate change disrupting fisheries, especially for Bagamoyo and Unguja, were hot temperatures, strong winds, and less rainfall. Higher temperatures together with strong winds compel fish to go deeper into the sea. Since artisanal fishers do not have the capacity to fish at deep seas, this has affected their catch significantly. Decreasing rainfall was also mentioned as a form of climate change contributing to less fish reproduction and ultimately less catch. One of
Table 2. Key Results of the Survey (%).

<table>
<thead>
<tr>
<th>Site</th>
<th>Ada East (N = 110)</th>
<th>Keta (N = 114)</th>
<th>Bagamoyo (N = 109)</th>
<th>Unguja (N = 108)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stressors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catch quantity changes in recent years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased</td>
<td>0.0</td>
<td>0.9</td>
<td>0.9</td>
<td>8.3</td>
</tr>
<tr>
<td>Decreased</td>
<td>90.0</td>
<td>99.1</td>
<td>85.3</td>
<td>78.7</td>
</tr>
<tr>
<td>No change</td>
<td>10.0</td>
<td>0.0</td>
<td>13.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Income changes compared to 5 years ago</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher</td>
<td>2.7</td>
<td>3.5</td>
<td>18.3</td>
<td>25.9</td>
</tr>
<tr>
<td>Lower</td>
<td>90.0</td>
<td>95.6</td>
<td>73.4</td>
<td>67.6</td>
</tr>
<tr>
<td>No change</td>
<td>7.3</td>
<td>0.9</td>
<td>8.3</td>
<td>6.5</td>
</tr>
<tr>
<td>Necessity for in-situ adaptation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government support in recent years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>51.8</td>
<td>36.0</td>
<td>32.1</td>
<td>30.6</td>
</tr>
<tr>
<td>No</td>
<td>47.3</td>
<td>57.9</td>
<td>47.7</td>
<td>38.8</td>
</tr>
<tr>
<td>I don’t know</td>
<td>0.9</td>
<td>6.1</td>
<td>20.2</td>
<td>30.6</td>
</tr>
<tr>
<td>Nongovernmental organization support in recent years</td>
<td></td>
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<tr>
<td>Yes</td>
<td>1.8</td>
<td>0.9</td>
<td>14.7</td>
<td>15.7</td>
</tr>
<tr>
<td>No</td>
<td>97.3</td>
<td>95.6</td>
<td>60.6</td>
<td>52.8</td>
</tr>
<tr>
<td>I don’t know</td>
<td>0.9</td>
<td>3.5</td>
<td>24.7</td>
<td>31.5</td>
</tr>
<tr>
<td>Intention of future out-migration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>70</td>
<td>69.3</td>
<td>51.4</td>
<td>60.2</td>
</tr>
<tr>
<td>If compensated</td>
<td>10.9</td>
<td>13.2</td>
<td>8.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Yes</td>
<td>13.6</td>
<td>7.0</td>
<td>35.8</td>
<td>36.1</td>
</tr>
<tr>
<td>I don’t know</td>
<td>5.5</td>
<td>10.5</td>
<td>4.6</td>
<td>0.0</td>
</tr>
<tr>
<td>In-situ adaptation strategies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changing fisheries techniques/gear</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Yes</td>
<td>3.6</td>
<td>3.5</td>
<td>22.0</td>
<td>38.9</td>
</tr>
<tr>
<td>No</td>
<td>96.4</td>
<td>96.5</td>
<td>78.0</td>
<td>61.1</td>
</tr>
<tr>
<td>Seeking other occupations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17.3</td>
<td>17.5</td>
<td>56.9</td>
<td>63.0</td>
</tr>
<tr>
<td>No</td>
<td>82.7</td>
<td>82.5</td>
<td>43.1</td>
<td>37.0</td>
</tr>
<tr>
<td>Agricultural land ownership</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>0.9</td>
<td>5.3</td>
<td>10.1</td>
<td>21.3</td>
</tr>
<tr>
<td>Borrowed</td>
<td>1.8</td>
<td>6.1</td>
<td>46.8</td>
<td>22.2</td>
</tr>
<tr>
<td>No</td>
<td>97.3</td>
<td>88.6</td>
<td>43.1</td>
<td>56.5</td>
</tr>
<tr>
<td>Joining associations/cooperatives more than 1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9.1</td>
<td>31.6</td>
<td>35.8</td>
<td>29.6</td>
</tr>
<tr>
<td>No</td>
<td>85.5</td>
<td>66.7</td>
<td>64.2</td>
<td>70.4</td>
</tr>
<tr>
<td>N/A</td>
<td>5.4</td>
<td>1.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

respondents in Bagamoyo reported that “high temperatures make fish unavailable so they go to deep waters where we cannot sail, and fewer rains result in less fish reproduction.”

Besides climate change factors, nonclimate change factors such as overfishing and light fishing were found to be significant factors. In all sites, households also mentioned that population growth has caused an increase in the number of fishermen, leading to overfishing. For Ghana, cases of illegal light fishing seem to be a peculiar problem (Figure 2). In Tanzania, overfishing and illegal fishing were mainly attributed to the increasing number of fishers, large vessels from foreign countries, and the use of destructive fishing gear such as beach seines and dynamite. Overexploitation of fishery resources does not only lead to a transformation of the structure of the populations and ecosystems but also to a reduction in the capacity and resilience of marine species and ecosystems to respond to climate change impacts (Belhabib et al., 2016).

Those impacts have not been alleviated by external support from government and NGOs including financial, educational, or other support (Table 2). Most of the fisherfolk in this study have not received any or are not aware of the existence of such aid. Especially with respect to NGOs’ support, very few respondents received support in both countries. Moreover, we found that households are reluctant to choose migration as adaptation options. Most respondents in all the communities chose negative answers for our question about potential migration (80.9% in Ada East, 82.5% in Keta, 59.6% in Bagamoyo, and 63.9% in Unguja). Considering that many would choose migration only if they were
compensated (job, land, or subsidy), there is a need for in-situ adaptation in the coastal communities where external support has so far been insufficient.

**Three In-Situ Adaptation Strategies of the Communities**

The third part of Table 2 shows the three in-situ adaptation strategies in the communities. The first strategy is a marine-based adaptation by changing non-destructive techniques/gear regularly, which can be considered in-situ intensification. The strategy also includes switching target fish species by seasonal changes or permanent changes. It has resulted in increased catch by avoiding the danger of fish catch decreases without adhering to the existing methods.

The second strategy is non-marine-based income diversification. The fisherfolk in all the communities pursued alternative in-situ occupations, keeping their fisheries at the same time. Figure 3 shows that farming is the most important economic activity in Tanzania. Wallner-Hahn et al. (2016) found that 40% of fishers on Unguja Island were engaged in farming in addition to fishing. Some of the main crops grown include cassava, maize, rice, and vegetables. In Ghana, small business operations were found to be the second income-generating activities after fishing. Carpentry, auto repair, selling fruit, and barbering were some of the commonly mentioned business activities. Those occupations contributed as sustainable income sources since fishing communities were able to earn income even during off seasons.

The last strategy is collective action with fisheries associations and cooperatives. Collective action is sources of other adaptation strategies, providing...
fisherfolk with material and nonmaterial benefits (Armitage, 2005; Freduah, Fidelman, & Smith, 2019). Memberships result not only in social benefits but also in financial benefits, fishing gear assistance, informational benefits, and political benefits when negotiations with government agencies and other organizations are needed.

Table 3 shows the results of chi-square tests of independence among the three strategies and fish catch/income changes. The results from the chi-square test of independence for each strategy are as follows:

### Table 3. Results of Chi-Square Tests of Independence.

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Fish catch not decreased&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Fish catch decreased</th>
<th>Total</th>
<th>Chi-square test of independence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing fisheries techniques/gear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14 (18.9%)</td>
<td>60 (81.1%)</td>
<td>74 (100%)</td>
<td>(\chi^2(1) = 4.702) (p &lt; .05)</td>
</tr>
<tr>
<td>No</td>
<td>37 (10.1%)</td>
<td>330 (89.9%)</td>
<td>367 (100%)</td>
<td>(\varphi = 0.103^b)</td>
</tr>
<tr>
<td>Total</td>
<td>51 (11.6%)</td>
<td>390 (88.4%)</td>
<td>441 (100%)</td>
<td>(n = 441)</td>
</tr>
<tr>
<td>Joining associations/cooperatives more than 1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11 (9.4%)</td>
<td>106 (90.6%)</td>
<td>117 (100%)</td>
<td>(\chi^2(1) = 0.586) (p = .44)</td>
</tr>
<tr>
<td>No</td>
<td>38 (12.0%)</td>
<td>278 (88.0%)</td>
<td>316 (100%)</td>
<td>(\varphi = 0.037)</td>
</tr>
<tr>
<td>Total</td>
<td>49 (11.3%)</td>
<td>384 (88.7%)</td>
<td>433 (100%)</td>
<td>(n = 433)</td>
</tr>
</tbody>
</table>

### Strategies Income not decreased<sup>a</sup> Income decreased Total Chi-square test of independence

- **Changing fisheries techniques/gear**
  - Yes: 22 (29.7%) 52 (70.3%) 74 (100%)
  - No: 58 (15.8%) 309 (84.2%) 367 (100%)
  - Total: 80 (18.1%) 361 (81.9%) 441 (100%)
  - \(\chi^2(1) = 8.042\) \(p < .005\) \(\varphi = 0.135^b\) \(n = 441\)

- **Joining associations/cooperatives more than 1 year**
  - Yes: 47 (27.8%) 122 (72.2%) 169 (100%)
  - No: 33 (12.1%) 239 (87.9%) 272 (100%)
  - Total: 80 (18.1%) 361 (81.9%) 441 (100%)
  - \(\chi^2(1) = 17.254\) \(p < .001\) \(\varphi = 0.198^b\) \(n = 441\)

### Note.
- \(\varphi\) = effect size (phi coefficient).
- The variables of fish catch/income changes are reclassified into two values (not decreased and decreased) because the authors considered “not changed” fish catch and income as “not decreased” and successful results of adaptation to vulnerability.
- \(\varphi\) significant difference with an effect size \(\geq\) Cohen’s definition of “small.”

The results from the chi-square test of independence for each strategy show that members of associations or cooperatives more than 1 year have a significant effect on income changes, whereas changes in fisheries techniques/gear do not significantly affect fish catch decreases. Seeking other occupations, on the other hand, significantly affects both fish catch and income changes.
analysis presented only give an indication of possible outcomes. To begin with, the first two rows present the relationship with fish catch changes. The strategy of seeking another occupation is excluded, as it is not marine-based. It turned out that the relation between changing fisheries techniques/gear and fish catch changes was significant, $\chi^2(1, n = 441) = 4.702, p < .05$. However, the relation between collective action and fish catch changes was not significant. This indicates that fisherfolk who changed methods were more likely to avoid fish catch decreases than those who adhered to the existing methods.

The last three rows show that all the strategies have significant associations with income changes. In the case of changing methods, the relation was significant, $\chi^2(1, n = 441) = 8.042, p < .005$. Moreover, the relation of seeking other occupations was significant, $\chi^2(1, n = 441) = 17.254, p < .001$. Likewise, the case of collective action showed a significant relation, $\chi^2(1, n = 433) = 4.599, p < .05$. In conclusion, fisherfolk who used the strategies were more likely to avoid income decreases than those who did not. These results from chi-square tests show that in-situ adaptation strategies can be recommended in terms of fish catch/income changes.

**Comparative Analysis**

**In-Situ Adaptation Differences Between Ghana and Tanzania**

On the basis of the results and analysis, we found that communities in Tanzania showed better performance compared to those in Ghana in relation to responding to changes and innovation. Tanzania showed a higher percentage of fishing households who use three strategies (Table 2). Related to sustainable bottom-up initiatives such as changes and intensification of nondestructive techniques and gear, the communities in Tanzania showed a higher proportion (22.0% and 38.9%) than those in Ghana (3.6% and 3.5%). Moreover, with respect to diversification, figures in Tanzania (56.9% and 63.0%) are much higher than those in Ghana (17.3% and 17.5%). Last, Tanzanian fishing households tend to join associations or cooperatives more than those in Ghana. Considering the significant relationship among all three strategies and income changes as mentioned earlier, these results can explain why the percentages of fishers with higher income, compared to 5 years ago, are higher in Tanzania (Table 2).

Furthermore, Ghanaian fishers tend to be more unaware of reasons of vulnerabilities. Perception of and knowledge of problems are vital to providing an adequate adaptation solution. Figure 2 shows that a significant number of fisherfolk in the study sites in Ghana claimed they did not know the reasons for declining fish catch (62.6% and 30.1%). In contrast, these percentages are considerable lower in Tanzania (6.5% and 8.2%). In addition, the Tanzanians
tended to know more specific information about climate change effects that can affect fish catch, such as stronger wind, hotter temperature, and wind direction.

We emphasize two reasons for different performances in the two countries in order to find implications for better in-situ adaptation and rural development in sub-Saharan Africa. First, there are more occupational opportunities in terms of land availability in the communities of Tanzania. For example, farming, as a major alternate income-generating activity in rural communities, could be constrained by factors such as land availability and ownership structure, the productivity of land, and the demand for products. A greater number of fisherfolk in Tanzania owned land. Table 2 shows that land ownership among fishers in Tanzania was about 10.1% (Bagamoyo) and 21.3% (Unguja) compared to just 0.9% (Ada East) and 5.3% (Keta) in Ghana. The causes of land shortage in Ghana can be found in population growth and expansion of residential areas, coupled with land erosion. Landlessness could be problematic in situations where there is a need for more livelihood diversification. Accordingly, additional strategies of adaptation are needed by alleviating the absence of adequate land in fishing communities.

Second, it is observed that fishers in Tanzania are more involved in collective action. Effective local participation means there are more possibilities for sharing information about vulnerabilities and adaptation strategies. This can explain why a greater number of fishers changed their techniques and gear in Tanzania in a sustainable manner. Moreover, associations and cooperatives provide more diverse benefits. While fisherfolk in Ghana might get financial, social, and educational benefits only, those in Tanzania could also expect material, political, occupational, and environmental benefits.

**In-Situ Adaptation Differences Within Ghana and Tanzania**

Besides agriculture, the study sites in Tanzania provide more opportunities from marine-based industries, especially tourism. While most alternative occupations in Ghana are in small shops (81%, Figure 3), those in Tanzania are quite diverse because of tourism, including work as hotel maids, tour guides, and cooks. According to the surveys, in Tanzania, several persons are engaged as tour guides (e.g., dolphin tours) with their own fishing boats, and they command higher salaries. Moreover, those opportunities are supported by the efforts of communities and local government, especially on Unguja Island. As a result, the monthly income from other occupations in Unguja ($43.2) is higher than in any other community ($10.3 in Ada East, $8.6 in Keta, and $25.8 in Bagamoyo). Unguja Island showed the highest level of education (upper level 50.9%). Bagamoyo recorded just 15.6% of fishers who have completed upper level/secondary school. This partly explains the increased opportunities in the tourism
industry for coastal communities, as more people can work in lower- and middle-level managerial positions with relatively short periods of training. Bagamoyo recorded the lowest median and average fisheries monthly income of $66.9 and $88.9, respectively (Table 1). In contrast, Unguja Island recorded twice the median fisheries monthly income of Bagamoyo, totaling $133.9 (Table 1). Fisherfolk in Unguja are more dynamic in terms of changing fisheries techniques/gear in response to decreasing fish catch and seasonal changes. Of the surveyed fishers in Unguja, 39% confirmed switching techniques, compared with 22% in Bagamoyo (Table 2). It is thus no surprise that monthly fisheries incomes are higher in Unguja. This finding is consistent with the earlier suggestion that fishers who change nondestructive techniques and gear regularly are less vulnerable to fish catch and income decreases than those who strictly adhere to the existing methods.

From Tables 1 and 2, we can deduct that educational attainment in Keta is higher (upper level, 25.4%) compared to Ada East (upper level, 12.4%), and more fishers join associations/cooperative groups in Keta (30%), compared to just about 10% in Ada East. Fishers belonging to associations/cooperatives benefit from financial, social, and educational support. Even more, fishers with modest education could get wage employment in marine and non-marine-based industries. This might explain why there is a reported decrease in the use of illegal light fishing and higher monthly incomes compared to Ada East (Tables 1 and 2 and Figure 2). The reasons for the general lack of interest by fisherfolk to join associations/cooperatives in Ghana could be due to the lack of trust and the manner in which various activities including associations and other related groups are highly politicized.

**Discussion**

The results of our empirical investigation enable to answer the third research question: Comparing the four study sites, under what conditions does in-situ adaptation thrive? Overall, the insights obtained point to two crucial issues: enabling institutional arrangements that incentivize biodiversity conservation and collective action. With respect to the former, curbing illegal fishing is fundamental. Coastal areas suffering from illegal fishing in Ghana (Figure 2) will find it hard to effectively engage in conservation and adaptation schemes. Interestingly, fishermen in the study sites at Ada East mentioned that they themselves do not use light in fishing but have spotted several boats using lights from the neighboring villages crossing over to their shore. They further explained that the bulk of the catch involving the use of light is fingerlings, thereby reducing the growth and reproduction of fish. This finding is consistent with a related study of Crawford, Gonzales, Amin, Nyari-Hardi, and Sarpong (2016). Furthermore, fisherfolk changing methods were more likely to avoid fish catch decreases than those who adhered to the existing methods. This corroborates Finkbeiner et al.’s (2017) claim that fisherfolk who participate in the exploration
and testing of new technologies can increase their effectiveness and practice of sustainable fishing.  

It is thus necessary to reinforce sustainability in terms of biodiversity conservation in coastal communities. Overall, overfishing appear to be a more immediate concern than climate change impacts. This is particularly evident in the case of Ghana where the 2002 Fisheries Act No. 625 (Section 81 (i)) seems to have failed. Whereas this Act prohibits the use of light and other destructive practices, we found that the practices are widespread. This is partly due to politics; in Ada East, a local fisheries watch dog committee could not be inaugurated because the local people saw the “government going partial”: The majority of the members of the watch dog committee were perceived to be affiliated to the ruling party in power. This is well articulated by a local community leader in Ada, saying “this area lacks effective traditional and political leadership.” Thus, lax enforcement has emboldened more fishers to use light fishing instead of adopting more sustainable fishing practices and finding other alternative jobs. This is quite a contrast with Bagamoyo in Tanzania where more people are now involving themselves in fish farming. One well-informed respondent mentioned “about 100 people are doing aquaculture, farming catfish and tilapia and this is a result of good motivation and economic changes. Some are also cultivating crops.”

Biodiversity conservation through curbing illegal fishing, promoting sustainable fish catch, and diversification needs effective forms of collective action. As pointed out in earlier sections, there is a lack of bottom-up initiatives, awareness, and trust in Ghana. By contrast, in the Tanzanian research areas fishing communities get together to share materials and jobs, strengthen their political voices, and clean the environment (which facilitates for instance growing seaweed). Indeed, Tanzania has had relatively more experiences with bringing together involved stakeholders: “We are making efforts together with our fisheries officers and BMUs (Beach Management Units) in conducting mangrove restoration, planting trees, providing education to the community on the importance and our roles in environmental conservation” (a civil servant, Department of Fisheries, Bagamoyo). A community leader in Bagamoyo provided further information on some of the specific roles played by BMUs: “BMUs are dealing with protection and managing the fisheries resources, these groups conducts patrols frequently in the fishing areas and landing sites for the inspections and taking actions for someone doing illegal fishing.” It is also worthy to acknowledge that the BMUs collaborate with other local community-based organizations to ensure food security and biodiversity conservation.

Overall, in-situ adaptation can serve as a viable strategy to improve coastal living standards. The participation of national and international development partners and NGOs could help improve food security and livelihoods across sub-Saharan Africa, but further empirical research is needed. Porter and Lyon (2006) warned that donor initiatives can be rejected by the intended recipients and that trust is vital to ensure effective collective action: “[…] the ability to
Table 4. Summary of Assessing In-Situ Adaptation in the Study Sites.

<table>
<thead>
<tr>
<th>Study sites</th>
<th>Ada East</th>
<th>Keta</th>
<th>Bagamoyo</th>
<th>Unguja</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversification</td>
<td>Some small businesses</td>
<td>Some small businesses and informal work</td>
<td>Agriculture and construction</td>
<td>Tourism and agriculture</td>
</tr>
<tr>
<td>Intensification</td>
<td>Illegal light fishing</td>
<td>Overfishing and use of dynamite</td>
<td>Changing fishing gear</td>
<td>Changing fishing gear</td>
</tr>
<tr>
<td>Innovation</td>
<td>Some entrepreneurship</td>
<td>Joining associations</td>
<td>Joining associations</td>
<td>Aquaculture such as seaweed farming</td>
</tr>
<tr>
<td>Success or failure factors</td>
<td>Absence of alternative occupation, reluctance to change gear, lack of information</td>
<td>Some benefits from collective action, reluctance to change gear, lack of information</td>
<td>Agricultural opportunities, diverse benefits from collective action</td>
<td>High education level, diverse benefits from collective action</td>
</tr>
</tbody>
</table>
build trust between group members may differ geographically, with variations in norms of behaviour and expectations” (p. 256). Furthermore, our research shows that collective action has higher chances of success if there is some land available. Without land diversification and innovation remains difficult, particularly in light of the strong wishes of coastal communities to stay where they are (Table 2).

**Conclusion**

Coastal fisheries communities in sub-Saharan Africa are under high socioeconomic vulnerability. Thus, it is important to set proper adaptation strategies in the communities by means of policies and support. The major findings from assessing in-situ adaptation in the study sites are as follows. First, the study finds the three major in-situ adaptation strategies to be changing nondestructive techniques and gear regularly, alternative occupations, and collective action. Second, all three strategies have a significant relationship with income change, and fisherfolk who adopt these strategies have been more likely to avoid income decreases. Third, the communities in Tanzania have utilized all three strategies more and have had higher percentages of fisherfolk with higher incomes. Table 4 provides a comparative summary of the main results.

Our results show that the reasons for vulnerability emanate from the complex interaction among climatic and nonclimatic factors. Therefore, remediation requires a holistic approach rather than simply restricting access to fishing with the aim of rebuilding depleted fish stocks (Finkbeiner, et al., 2017; Overå, 2011). Despite being under similar vulnerabilities, the results of in-situ adaptation strategies varied between communities and countries. This gives rise to the importance of regional inequalities as well as the need to keep in mind the complex relationships between overfishing, climate change, and poverty dynamics (Kalikoski et al., 2018; Sánchez, 2018).

Kosamu (2015, p. 372) wrote that “(re)building local collective social capital”, in which trust is an important element, is the only way forward in order to create sustainable small-scale fisheries communities. The more favorable conditions in Bagamoyo and Unguja support this conclusion in that bottom-up initiatives through BMUs functioned more effectively with the key in-situ adaptation strategies of intensification, diversification, and innovation (Table 4). Monitoring by BMUs encourages sustainable intensification as they prevent community members from falling into the tragedy of the commons.

Therefore, we argue that fostering collective action initiatives should be better aligned with the three elements of in-situ adaptation. Following the Tanzanian cases, it appears to be necessary to involve local cooperatives and associations for managing fisheries resources and related socioeconomic habitats. Such organizations are, when well-managed, likely to be effective in terms of monitoring and
fostering human capital. In addition, local and provincial government agencies could contribute to thriving coastal communities by creating programs for community leaders to share knowledge about sustainable, innovative fishing methods, conflict resolution, food security options, as well as about encouraging a circular economy. Depending on the location, creating sustainable artificial reefs, planting coconut trees, and setting up plastic waste processing facilities to clean up beaches could be viable options. Finally, several issues cannot be solved at the subnational level, but need to be addressed at the national or even international level. One can think of the complex issues of land reform in coastal areas as well as illegal, unreported, and regulated fishing by foreign vessels.

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Notes
1. Note that vulnerability often evolves in multiple ways and can be both a stressor and outcome; “Ultimately, vulnerability reflects the nature, strength, diversity of people’s livelihoods” (Gaillard, 2015, p. 11).
2. The number of LDCs is 47 in 2018, and most of them including Tanzania are African nations (33 countries). Ghana was eligible for LDC status but declined to be on the list (United Nations, 2015).
3. Light fishing is a type of fishing methods using a light attached above water or underwater to attract both fish and their food chain to harvest them. It usually involves the use of generators and 1,000-W bulbs laid into the sea (Afoakwah, Osei, & Effah, 2018).
4. This might explain why respondents in Ghana perceived climate change factors to be relatively less severe.
5. A good example of unsuccessful support from governments is the introduction of “marine protected areas.” Only 3.1% of fisherfolk are aware of this introduction.
6. Negative answers included “never” and “if compensated” in Table 2.
7. This implies that intensification can be sustainable in the long run.

References


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